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UAVs: Holy Grail for Intel, Panacea for RSTA, or Much Ado about Nothing? UAVs for the Operational Commander

by

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A paper submitted to the Faculty of the Naval War College in partial satisfaction of the requirements of the Department of Joint Military Operations.

The contents of this paper reflect my own personal views and are not necessarily endorsed by the Naval War College or the Departments of the Navy or the Army.

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ABSTRACT

The Unmanned Aerial Vehicle (UAV) is a force multiplier for the operational commander. Characterized as either lethal or non-lethal and employed singularly or as a system of systems, they significantly enhance a combatant or joint force commander's ability to satisfy strategic, operational, and tactical objectives. UAVs have supported military operations including the Vietnam War, the 1983 Israeli War, the Gulf War and most recently the United Nations Peace Keeping Operation in Bosnia, to name a few. Although U.S. UAV acquisition programs have followed a very rocky road to date, slowing their evolution, their future is promising. Non-lethal UAVs are intended to operate as a system of systems to provide blanket coverage for the commander in conjunction with other manned and satellite systems. Non-lethal UAV missions include RSTA, intelligence, and BDA. Lethal UAVs are essentially smart bombs that can locate, identify and attack a target. If a suitable target is not identified, they can return to fight another day. Advantages to using UAVs over manned platforms are that they provide a low risk, highly efficient and effective, and low cost solution to fighting wars and MOOTW. This is especially important in today's world of decreasing resources and increasing responsibilities. Today, UAVs uniquely support the operational functions of Operational Art and are equally suited to supporting the operational concepts of Joint Vision 2010. Whether providing eyes on target, steel on target, or acting as a virtual communications satellite, UAVs provide the force commander with a low-risk high-payoff approach to warfighting. UAVs are a force multiplier for the operational commander.

Introduction

The Unmanned Aerial Vehicle (UAV) is a force multiplier for the operational commander. Characterized as either lethal or non-lethal and employed singularly or as a system of systems, they significantly enhance a combatant or joint force commander's ability to satisfy strategic, operational, and tactical objectives – effectively and efficiently. They are battle tested and have performed in an exemplary manner across the spectrum of conflict, from war to military operations other than war (MOOTW). However, UAV contributions to past and present operations, dynamic and successful as they have been, barely scratch the surface in demonstrating the role that they can play. Unfortunately, UAV acquisition programs have followed a very rocky road to date. This has slowed the evolution of UAV concepts and technologies. The good news is that with the rapid evolution of technology, an increase in congressional support and warfighter demands, UAV programs are getting in step. Although not a Holy Grail for intelligence or a panacea for reconnaissance, surveillance, and target acquisition (RSTA), their use incurs tremendous advantages. Additionally, they are uniquely suited to future joint doctrine requirements (Joint Vision 2010). The future is bright for UAVs. Their role as a combat multiplier for the operational commander is brighter.

Background

UAVs prior to the 1990's were widely referred to as remotely piloted vehicles (RPVs). UAV and RPV are generally considered to be synonymous and will be considered as such in this paper. The term drone should not be confused, however, with UAV and RPV. A drone connotes a small, expendable vehicle that is most often used in research, testing, and surface to air and air to air target practice. Structurally, drones are incapable of supporting the requisite payloads to act as lethal or non-lethal weapons systems. Joint Pub 1-02 defines the following:

RPV - An unmanned vehicle capable of being controlled from a distant location through a communication link. It is normally designed to be recoverable.[1]

UAV - A powered, aerial vehicle that does not carry a human operator, uses aerodynamic forces to provide vehicle lift, can fly autonomously or be piloted remotely, can be expendable or recoverable, and can carry a lethal or nonlethal payload. Ballistic or semiballistic vehicles, cruise missiles, and artillery projectiles are not considered unmanned aerial vehicles.[2]

UAVs – tried, tested, and true

To say that UAVs have now come of age, as some have stated, suggests that the impact of UAVs is just now being felt. In a way this discredits the significant contributions that UAVs have made over the past thirty plus years. UAV development received its first boost following the downing of the U2 spy-plane piloted by Francis Gary Powers over the USSR in 1960. The operations and conflicts stated below and the downing of additional U.S. aircrews abroad (e.g., Lt. Goodman – Lebanon, 1983 and Capt. O'Grady – Bosnia, 1995) further advanced the requirement to develop and field UAVs that could perform high-risk missions instead of or complementary to manned platforms. UAVs have supported covert and overt surveillance operations over Cuba and China and they have supported military operations including the Vietnam War, the 1983 Israeli War, the Gulf War and most recently the United Nations Peace Keeping Operation in Bosnia, to name a few. The latter operations will be discussed in greater detail below.

Vietnam War. UAVs were used extensively during the conflict due to the high rate of manned aircraft losses the U.S. was encountering operating over North Vietnam. UAVs flew more than 3000 sorties over North Vietnam "...photographing targets for air attack, recording damage after bombing, and even discovering unsuspected key targets like the huge North Vietnamese fuel storage areas in a suburb of Hanoi...Other military applications included dispensing American propaganda leaflets over North Vietnam and carrying electronic listening transceivers to pick up and relay enemy broadcasts."[3] Flying preprogrammed routes, UAV losses

were relatively low at less than ten percent.[4] The concept of using UAVs for reconnaissance and surveillance over heavily defended enemy territory came to fruition during this time period when U.S. tolerance for the war effort was running thin and losses of manned aircraft/aircrews were exceedingly troublesome to that effort.

Israeli War of 1983. The Israeli War against Syria is the only non-U.S. operation that I will discuss. Without question this conflict did more to accentuate the need for UAVs than any other and is the baseline from which current day concepts and programs were born. Derivatives of the air vehicle used in that conflict are still used today by Israeli and U.S. forces (i.e. Pioneer and Hunter). The Israelis used UAVs to perform electronic surveillance, electronic warfare, and electronic attack to masterfully execute a suppression of enemy air defense (SEAD) plan. As Millis notes:

> The RPVs flew into the Bekaa Valley emitting the electronic image of an Israeli fighter. When the Syrian radars were activated, RPVs relayed the radar's "signature" to AWACS control planes orbiting some distance away...These in turn, advised Israeli pilots of the proper jamming frequencies and called for artillery fires (adjusted by RPVs) to harass air-defense ground crews while chaff-dispensing rockets obscured the radar image of the in-bound fighters. F-4 Wild Weasel aircraft then arrived, dispensing diversionary flares, and firing either modified Shrike radar-homing missiles or "smart" bombs which were guided to their targets by the RPVs' laser target designator.[5]

Additionally, Israeli UAVs loitered over Syrian airfields and identified and reported on Syrian aircraft taking off to Israeli intercept aircraft. The operation resulted in only one loss of an Israeli manned aircraft – at the cost of no less than 86 Syrian fighters.[6]

Gulf War. The Gulf War was the first operational employment of UAVs in a joint and combined hostile operation by U.S. forces and they performed exceedingly well. The U.S. deployed and operated two tactical systems, Pioneer and Pointer. Pioneer is similar to the UAVs used by the Israeli's in 1983. Six units, (one Army, two Navy, and three Marine Corps), deployed and performed intelligence, RSTA, and battle damage assessment (BDA) missions in close and deep operations. Pointer, a small hand launched system capable of being broken down and

transported by light infantryman, performed the same missions but was exclusively a close battle asset. The Army's 82nd Airborne Division and the Marine's First Expeditionary Force and 4th Marine Expeditionary Brigade operated Pointer.

Pioneer flew 307 flights and 1,011 flight hours during Desert Storm and flew 523 missions and 1,559 flight hours total.[7] Significant is that "...The Marines did not lose a single RPV in more than 1,000 hours of flight during the war. Overall only one Pioneer...was lost to hostile fire (11 others were destroyed due to mechanical failure, electromagnetic interference or operator error)...At least one Pioneer was in the air at all times during the six-week war."[8] The Pioneer, as stated, performed exceedingly well. Although the system failed to meet all of the program's operational requirements, it deployed to the region and was lauded for its RSTA, intelligence, and BDA contributions. Pioneer was even accredited for the surrender of an Iraqi unit, "The Iraqi soldiers on Faylakah Island that day waved handkerchiefs, undershirts, and sheets – anything that would signal submission to the strange airplane that soared above them like the herald of doom."[9] The Iraqi's acted this way because "So often before, the appearance of this evil vehicle was followed by a rain of destruction; this time the Iraqi's sought to forestall death with surrender."[10] Maj. Gen. Menoher, Commanding General of the U.S. Intelligence Center and School, best captured the impact of UAVs on commanders by saying "Desert Storm made more friends for UAVs than you can imagine. Now every field commander wants them."[11]

Bosnia. Although the French, CIA, and DOD have operated UAVs over Bosnia to date, I will only address the DOD's employment of UAVs in support of UN peacekeeping operations. The DOD has operated two systems since 1995, Predator and Pioneer. As successful as UAVs have been supporting operations in war, "UAVs have [also] proven to be a very useful resource in peacekeeping operations since they provide an unobtrusive reconnaissance capability with no risk of losing air-crews in a politically-charged situation."[12] This MOOTW role for UAVs is rapidly evolving in Bosnia and their achievements to date are many. Speaking only of Predator, it

has "...logged 2,436 mission hours over Bosnia since 1995."[13] Predator disseminates its imagery to multiple sites in the theater and via satellite relay can disseminate near-real time imagery worldwide, limited only by the inherent delay times associated with that transmission means. The Defense Airborne Reconnaissance Office (DARO) captures a key example of the usefulness of UAVs in Bosnia in a 1996 UAV Annual Report,

> With Predator, however, weapons movements became subject to long-dwell video surveillance, and continuous coverage of area roads showed no evidence of weaponry being withdrawn. This single ISR resource thus gave NATO commanders the key piece of intelligence that underlay their decision to resume the bombing campaign that, in turn, led to the Dayton peace accord signed in December 1995.[14]

The report goes on to identify other notable UAV (Predator and Pioneer) accomplishments. They include:

- aided search for downed pilots
- imagery proved Serbs had not withdrawn forces threatening Sarajevo and Gorazde
- imagery helped NATO targeting
- monitored mass grave sites near Sarajevo, which provided evidence of 1995 massacres
- quick-response observations to preclude confrontations between factions or with NATO units
- surveillance of population centers, suspected terrorist training areas, and route reconnaissance[15]

Lastly, Predator was even credited with ensuring the safety of the Pope during a visit to the region by monitoring parade routes and tracking suspected war criminals such as Radovan Karadzic.[16]

In sum, UAV accomplishments in war and MOOTW have come a long way in showing their usefulness. Battle and operationally tested, I will next discuss UAVs status in the U.S. military.

Non-lethal and lethal UAVs

Based on the bright picture painted above and their desire by commanders, it may be surprising to note that UAV acquisition and development is not significantly further along than it

was 10 years ago. Through the years UAV programs have encountered numerous cost overruns, setbacks, and changes in operational mission requirements. Most would argue that this is par for the course and typical of other DOD acquisition efforts. In testimony before Congress Louis J. Rodrigues stated on 9 April 1997,

> ...its [DOD] objective in acquiring UAVs is to provide unmanned systems that will complement its mix of manned and national reconnaissance assets. However, its UAV acquisition efforts to date have been disappointing. Since Aquila began in 1979, of eight UAV programs, three have been terminated (Aquila, Hunter, Medium Range), three remain in development (Outrider, Global Hawk, DarkStar), and one is now transitioning to low rate production (Predator). Only one of the eight, Pioneer, has been fielded as an operational system. We estimate DOD has spent more than $2 billion for development and/or procurement on these eight UAV programs over the past 18 years.[17]

There are two program categories for the development of UAVs in DOD: non-lethal and lethal. Non-lethal UAVs are included in the UAV Joint Program Office (JPO) master plan while lethal UAVs are included in the conventional weapons standoff master plan.

The JPO was formed in 1988 in response to criticism by Congress to take charge of the service's mismanagement of individual UAV programs, which were incurring enormous costs and were seemingly going nowhere. The JPO's charter was to "jointize" and formulate the requirements of U.S. forces for non-lethal UAVs of the 1990s and beyond.[18] The JPO is now under DARO, which was created in 1994 "...to develop and maintain the DOD's integrated airborne reconnaissance architectures as a framework for the development and acquisition of improved airborne reconnaissance capabilities."[19] DARO is responsible for managing six programs in two basic categories: tactical (Outrider and Pioneer) and endurance (Predator Medium Altitude Endurance (MAE), Tier 2; Global Hawk High Altitude Endurance (HAE), Tier 2+; and DarkStar Low Observable High Altitude Endurance (LO-HAE), Tier III -). The capabilities and missions of these UAVs are contained in the appendix.

While it is true that only one of the six programs has been operationally fielded to date, one additional (Predator) has entered low rate production and three (Outrider, Global Hawk, and DarkStar) are in Advanced Concept Technology Demonstrations (ACTD). The importance of non-lethal UAVs cannot be overstated. "Most manned reconnaissance aircraft are being phased out of the Air Force inventory. By the end of the century, the US arsenal of penetrating reconnaissance systems will consist primarily of UAVs."[20] The good news is that "The Congress has been very supportive of the Department's [DARO] UAV programs and, for the third year in a row, has added funds to our UAV efforts. In addition, the Joint Requirements Oversight Council (JROC) prioritized UAV programs and provided stability in the joint requirements process that supports warfighter needs."[21]

Non-lethal UAVs are intended to operate as a system of systems to provide blanket coverage for the commander in conjunction with other manned and satellite systems. Ultimately, UAVs will "...help commanders at different echelons to 1) know what is on or approaching the battlefield before their forces get there, and 2) employ forces and weapon systems more efficiently as the result of precision targeting and BDA information."[22]

Lethal UAVs, also referred to as uninhabited combat air vehicles (UCAVs), are "sophisticated 'smart' weaponry...featuring an 'intelligent' guidance system."[23] The general concept of lethal UAVs is that they can be launched from afar and find their own target, at which time they can destroy it or continue to loiter for a better target, or return to base for use another day. To further reduce the cost of the UCAV, it can operate sensor smart and bomb dumb (non-precision type using the air vehicle sensor suite for precision to deliver the goods - personally). It can also operate sensor dumb and bomb smart (use sensors of other platforms such as JSTARS or Rivet Joint to identify, locate, and designate targets). "Probably the best example of a lethal UAV is the Tacit Rainbow emitter attack weapon, which has some missile-like capabilities with

its small turbine engine. It has the capacity to fly autonomously, loiter in a predetermined area and then detect, classify and attack."[24]

Force multiplier for the operational commander

UAVs provide combatant and joint force commanders with a significant force multiplier. Not unlike manned platforms performing like missions, they enable commanders to find, fix, and fight the enemy. However, manned platforms are just that, manned, and they are generally much larger, less flexible, and cost much more money to develop, field, and sustain. UAVs on the other hand provide a plethora of low risk and highly effective, efficient, and low cost systems for them to pull from their rucksack to accomplish the venerable mission requirements specified and implied in the execution of wars and MOOTW. UAVs are particularly adept at performing the Three-Ds: dull, dirty, and dangerous.[25] In today's world of decreasing resources and increasing responsibilities UAVs provide the force commander the ability to do better with less. Doctrine states that each service will operate, maintain, train, and fight their organic UAV systems. However, each service provides this capability for use by the combatant or joint force commander whenever and wherever required as a member of the joint force team. Some of the more significant advantages and disadvantages for the use of UAVs are contained below.

Advantages. The advantages of employing unmanned platforms in support of U.S. forces are essentially the same for non-lethal and lethal systems; therefore, no distinction will be made between the two. The greatest benefit of using UAVs over manned platforms is the inherent low risk to personnel associated with their use. Mentioned previously was the success rate of UAVs in support of operations in Vietnam. What necessitated their use was the high loss of aircrews and aircraft. "Of the American prisoners of war held in Southeast Asia, almost 90 percent were downed pilots and crewman and over 5,000 Americans lost their lives in hostile and nonhostile aircraft during the war."[26] This is staggering considering that today the American way of war makes the loss of even a single life seem unacceptable. The elimination or reduction in aircrew

losses would occur with the widespread use of UAVs. UAVs reduce the political risk of conducting operations as well. UAVs have been lost over China, Vietnam, and Bosnia with nary a mention on the international scene. UAVs just do not connote the same level of direct involvement or embarrassment when compared to the loss of an aircraft and aircrew (e.g., Francis Gary Powers over the USSR, Lt. Goodman over Lebanon, aircrews over Iraq during the Gulf War, or Capt. Scott O'Grady over Bosnia). Essentially it reduces the propaganda value of the incident.

UAVs measurably increase the efficiency and effectiveness of military operations. They provide the commander an organic capability, they are flexible, and UAV payloads are comparative and sometimes superior to that found on manned platforms. The intelligence capabilities that UAVs provide the commander are significant and are "...a revolution in intelligence gathering. Instead of begging the National Command Authorities (NCA) for a satellite pass or a U-2 flight, theater-level commanders will have their own extremely capable assets."[27] The idea of deploying a UAV over 1,000 miles, having it arrive ready to loiter an area for over 40 hours, and having it immediately collect and disseminate information is staggering.

UAVs are flexible. They can be operated from afar or from airfields, ships, and roads (improved and unimproved) within the theater of operations. Their ability to loiter for extended periods (4 to more than 40 hours) over the target area and their inherent survivability (i.e., low radar cross section, slow speed, size, and composition) make UAVs easier and safer to dynamically task. Additionally, UAVs are easier to deploy since their logistics and operational tails are much smaller than their manned counterparts.

UAVs are also effective and efficient due to the advanced sensor systems they possess and in one case due to stealth technology (LO-UAV). Benefiting from miniaturization and advances in technology, UAVs can employ sensors individually or in conjunction with other

systems. Payloads are varied and are adaptable to any operational requirement. Following are examples of demonstrated and demonstration payloads:

Non-lethal

- Imagery Intelligence Payload (IMINT)
- Meteorologic Sensor
- Radiac Sensor
- Lightweight Standoff Chemical Detector
- Lightweight Comms Intelligence (COMINT) and Electronic Intelligence Payloads (ELINT)
- Coastal Battlefield Recon and Analysis (COBRA)
- Tactical Remote Sensor System (TRSS)
- Communications Relay
- Laser Designator/Rangefinder
- Comms and Radar Jamming Payloads[28]

Lethal
(Platforms as opposed to payloads)

- Converted F-16
- Variations of the Joint Strike Fighter
- Scaled up Cruise Missile[29]

Two examples of advanced technologies are Predator's COMINT and synthetic aperture radar (SAR) payloads. Acting as a virtual satellite, the Predator COMINT payload is "...sensitive enough to pick up low-power walkie-talkie or cellular phone conversations and retransmit them to allied intelligence officials for analysis."[30] Predator's SAR (IMINT type) payload is considered by many to be superior to the U-2s and has the ability to process the imagery on board the platform, which enables quicker dissemination.[31] The systems potency is increased since its sensors can be placed wherever needed to optimize its capabilities, without the fear of loss of human life.

The final significant advantage is cost. UAVs, regardless of the acquisition difficulties they have suffered, do not come close to the development, acquisition, fielding, or operating costs of manned platforms. To accentuate this Stan Crock and Neal Sandler state that "UAVs tickle the fancy of war planners because unmanned means cheap. Outriders (TUAV) will cost as little as $300,000, and the tab for the attack UAVs might be just $10 million -- compared to $30

million for the proposed Joint Strike Fighter. And combat training for UAV jocks would be like learning a video game -- far cheaper than logging thousands of hours of flight time."[32] They go on to quote Defense Secretary Cohen as saying "At some point…you'll find much greater utilization of UAVs than ever before."[33] Additional savings are reaped since the logistics and operational infrastructures are smaller and the overall cost of training an UAV controller is substantially less than that of an aircrew member. A GAO report captures the last point by stating, "Disregarding humanitarian considerations, the capital investment lost when a pilot is killed or incapacitated is sufficient to make the use of RPVs a logical alternative whenever possible."[34] Lastly, the inherent survivability of the platforms make them a bargain by being able to purchase more for the dollar and ensuring that the system will be around to fight another day.

Disadvantages. Like everything in life there are always two sides to the story. Opponents of UAVs have traditionally fallen into two camps, technical and human. On the technical side they cite a number of UAV pitfalls. These include poor survivability, insufficient payload technologies, and environmental restrictions to flight. The human camp focuses on taking humans out of the loop and away from the ability to use logic and judgment to avert or remedy a crisis. The vast amount of flight hours and operational experience that UAVs (including the many UAVs not mentioned here in operation worldwide) have accumulated negate this argument. There is still a pilot at the controls – just not in the air vehicle. Rather, they are in a vehicle, on a ship, in another aerial platform, or in a submarine. Additionally, there still exists the feeling that since UAVs take pilots out of the cockpit, so too they take away pilots jobs. This argument is already abating itself – UAVs are just too dynamic and useful not to appreciate their potential.

Countering the technological arguments is rather easy. Citing the crash of two Predators in Bosnia, naysayers quickly jumped at the survivability issue by stating that UAVs are just too slow to effectively evade hostile fire. The simple fact is that UAVs are inherently survivable. Their slow speeds and low radar crosssections makes locating and tracking them on conventional

radars extremely difficult. Additionally, due to their size and normal operating altitudes they are very difficult to visually acquire and virtually impossible to hear. Lastly, Ray Coleman of the JPO was "...quick to compare the loss of the two unmanned Predators over Bosnia with the downing there of the fighter piloted by Air Force Capt. Scott O'Grady. "Those two craft are heroes"...they did exactly what we wanted them to do. The ultimate purpose of UAVs is to go somewhere and get shot out of the sky so Capt. O'Grady doesn't have to anymore."[35] Concerning the issue of redundancy in air vehicle control, although never assured, technology has improved significantly and is more prone to human error than equipment malfunction. For example, a Hunter UAV data-link, used to manually control the air vehicle in flight, failed while flying over the south Arizona desert a few years ago. The UAV proceeded to fly south through Mexico to the Pacific Ocean where it ran out of gas and landed (the air vehicle was recovered by a Mexican fishing vessel and by Mexican authorities). As it turned out, after the air vehicle lost link it returned to the "home" coordinates put in by UAV ground support personnel, whom it was discovered later had put in the wrong coordinates. The first Predator mission in Bosnia suffered the same loss of link but in its case it did return as directed and the bird was recovered safely. Lastly, while UAVs are in no way meant to be expendable, their low cost make survivability less of an issue.

Of the second and third disadvantages, poor payload technologies and poor environmental flight capabilities, the first was addressed previously. Payload technologies have matured significantly over the past few years and are currently being fielded and tested in operational and demonstration systems. For example, Predator has a thermal imager and color daylight television that "...permits identification of a person at a range of some 5km. Early trial imagery at Edwards AFB in California clearly shows C-130s taxing from a slant range of more than 43km."[36] The environmental flight issue is still valid; however, it effects tactical UAVs (Pioneer, Hunter, and Outrider) more than the endurance UAVs due to their small size and

minimal weight and power generating capabilities. Engines, airfoils, and propellers are being modified and redesigned to eliminate icing and de-lamination problems, but it must be noted that even manned systems are not devoid of environmental difficulties. Predator has recently been outfitted with de-ice and anti-ice capabilities; Global Hawk and DarkStar operate at altitudes where environmental limitations are normally not encountered. In sum, UAVs do have disadvantages that must be considered when planning for their use, but just like manned platforms, employment considerations must be made with a keen eye to capabilities and limitations. Fortunately the disadvantages are slight. The bottom line is that UAVs promise the warfighter big bang for the buck at reduced risk and cost – a true force multiplier.

Supporting the future fight

Edward Teller stated that "The unmanned vehicle is a technology akin to the importance of radar and computers in the 1935."[37] While this is as true today as when the statement was made 16 years ago, UAVs still do not exist in sufficient quantities to satisfy combatant and joint force commanders needs. Everyone wants them but there just are not enough of them to go around. The Vietnam War notwithstanding, as early as 1984 "the fleet commander off Lebanon...made it very clear that he saw an immediate need for RPVs'...His request was seconded by the theater commander and ultimately by the Joint Chiefs of Staff."[38] Another example is a SOUTHCOM statement made concerning Operation Just Cause, "Soldiers' lives were compromised...due to the lack of Unmanned Aerial Vehicles. Such UAVs would have enhanced US forces reconnaissance, targeting, and attack capabilities."[39]

As UAV demonstrations evolve and the acquisition and fielding of systems gains momentum, planners and warfighters will become more familiar with their use and potential uses. This will result in the development of advanced concepts that best take advantage of the unique capabilities that UAVs offer. Whether providing an umbrella of surveillance, acting as a virtual communications satellite, or by providing eyes or steel on target, UAVs support the

operational functions of movement and maneuver, C^2, intelligence, fires, and protection. Due to their flexibility, depth, and low risk efficiency, UAVs provide operational commanders with the ability to synchronize, arrange, and balance forces to best achieve operational objectives – with the principles of mass and economy of force both being adhered to. Lastly, lethal UAVs will provide combatant commanders with the ability to employ operational fires with the type of high-precision low-risk efficiency currently unavailable.

UAVs and JV 2010. With an eye to the future "Joint Vision 2010 is the conceptual template for how America's Armed Forces will channel the vitality and innovation of our people and leverage technological opportunities to achieve new levels of effectiveness in joint warfighting."[40] UAVs are well adept at supporting this concept. In a period of reduced resources, UAVs are systems that provide the operational commander with the ability to do less better, at significantly reduced risk and cost. They will enhance the warfighter by providing information superiority – the cornerstone of full spectrum dominance. UAV development focuses on a system of systems approach to meet the operational concepts of Joint Vision 2010. Tactical and endurance systems will contribute in the following ways:

> <u>Dominant Maneuver</u> – all-weather, accurate and timely imagery to meet tactical and theater needs
>
> <u>Precision Engagement</u> – short and long-range target ID, geolocation and cueing, plus BDA
>
> <u>Full-dimension protection</u> – direct support to tactical echelons with reduced risk to personnel, wide-area/long-dwell/stealthy, increase situational awareness
>
> <u>Focused Logistics</u> – simplified support via HFE and sensor commonality, information and link standards[41]

UAVs will continue to mature and give the combatant and joint force commander enhanced command and control capabilities, accurate and timely information, and a long-range precision capability needed to support future contingencies. The ability to perform these

functions will allow the operational commander to effectively employ the principles of war and MOOTW in planning and execution.

Conclusion

"For years warfighters have articulated the needs for situational awareness, target identification, dominant battlefield awareness, dominant battlespace knowledge, and information superiority. Now we have the ability to move from words to deeds."[42] UAV prospects are limitless, confined only by congressional support, developing concepts, and warfighter support. Missions include:

Non-lethal

- RSTA
- Search and rescue and combat search and rescue
- Deception operations
- Maritime operations (naval surface fire support; over-the-horizon targeting; ship classification; anti-ship missile defense; antisubmarine warfare; and mine defense support)
- Electronic warfare, SIGINT, ELINT, and directed energy sensor reconnaissance
- Nuclear, biological, and chemical reconnaissance
- Special and psychological operations (re-supply for special operations and psychological operations teams and leaflet delivery and broadcast)
- Meteorology missions
- Route and landing zone reconnaissance
- Adjustment of indirect fires and close air support to include operational fires
- Rear area security support
- BDA
- Communications relay[43]

Lethal

- SEAD
- Deep penetration strikes
- Theater ballistic missile defense
- Cruise missile defense
- Air-to-air combat[44]

UAV potential is limitless. Dick Wagaman, former President of the Association of Unmanned Aerial Vehicle Systems, stated at the UV'95 Unmanned Aerial Vehicles Conference that "UAVs are being used for more functions everyday...While image intelligence will provide the bulk of immediate buys in the near term, ESM, EW,

communications and other tactical roles are being adopted for UAVs."[45] Battle proven and multifaceted, UAVs provide commanders with a low-risk high-payoff approach to warfighting – they are truly a force multiplier.

Recommendations

- Aggressively develop, acquire, test, and field UAVs – get them out to the force so that they are ready to support the combatant and joint force commander

- Integrate UAV testing with joint and combined exercises at every opportunity to develop concepts, tactics, techniques, and procedures (TTPs), and doctrine for their use

- Increase congressional and military exposure to the capabilities and limitations and the strategic, operational, and tactical significance of UAVs for funding and prioritization

APPENDIX

	CHARACTERISTICS	Pioneer	Hunter	Tactical UAV *Outrider*	Tier II, MAE UAV *Predator*	Tier II+, CONV HAE UAV *Global Hawk*	Tier III–, LO HAE UAV *DarkStar*
Operational	ALTITUDE: Maximum (km, *ft*) Operating (km, *ft*)	4.6 km *15,000 ft* ≤4.6 km *≤15,000 ft*	4.6 km *15,000 ft* ≤4.6 km *≤15,000 ft*	4.6 km *15,000 ft* 1.5 km *5,000 ft*	7.6 km *25,000 ft* 4.6 km *15,000 ft*	19.8 km *65,000 ft* 15.2–19.8 km *50,000–65,000 ft*	>13.7 km *>45,000 ft* >13.7 km *>45,000 ft*
	ENDURANCE (Max): (hrs)	5 hrs	11.6 hrs	>4 hrs (+ reserve) @ 200 km	>20 hrs	>40 hrs (24 hrs at 5,556 km/*3,000 nm*)	>8 hrs (at 926 km/*500 nm*)
	RADIUS OF ACTION: (km, *nm*)	185 km *100 nm*	267 km *144 nm*	≥200 km *≥108 nm*	926 km *500 nm*	5,556 km *3,000 nm*	>926 km *>500 nm*
	SPEED: Maximum (km/hr, *kts*) Cruise (km/hr, *kts*) Loiter (km/hr, *kts*)	204 km/hr *110 kts* 120 km/hr *65 kts* 120 km/hr *65 kts*	196 km/hr *106 kts* >165 km/hr *>89 kts* <165 km/hr *<89 kts*	204 km/hr *110 kts* 167 km/hr *90 kts* 111-139 km/hr *60-75 kts*	204-215 km/hr *110-115 kts* 120-130 km/hr *65- 70 kts* 111-120 km/hr *60- 65 kts*	>639 km/hr *>345 kts* 639 km/hr *345 kts* 630 km/hr *340 kts*	>[illegible]/hr *>250 kts* >[illegible]/hr *>250 kts* >46[illegible] km/hr *>250 kts*
	CLIMB RATE (Max): (m/min, *fpm*)	[N/A] [N/A]	232 m/min *761 fpm*	488 m/min *1,600 fpm*	168 m/min *550 fpm*	1,036 m/min *3,400 fpm*	610 m/min *2,000 fpm*
	DEPLOYMENT NEEDS:* *Depends on equipage & duration	Multiple* C-130, C-141, C-17 or C-5 sorties Ship: LPD	Multiple* C-130 sorties	Single C-130 (drive on/drive off) Ship: LHA/LHD (roll on/roll off)	Multiple* C-130 sorties	AV: Self-Deployable GS: Multiple* C-141, C-17 or C-5 sorties	Multiple* C-141, C-17 or C-5 sorties
Air Vehicle	PROPULSION: Engine(s) – Maker – Rating – Fuel – Capacity (L, *gal*)	One Recip; 2 cylinders, 2-stroke – Sachs & Fichtel SF 2-350 19.4 kw *26 hp* AVGAS (100 octane) 42/44.6 L *11/12 gal*	Two Recips: 4-stroke – Moto Guzzi (Props: 1 pusher/1 puller) 44.7 kw *60 hp* MOGAS (87 octane) 189 L *50 gal*	One Recip; pusher prop – McCulloch 4318F Short Block/Diesel 37.3 kw *50 hp* Heavy Fuel (JP-8) 48 L *12.7 gal*	One Fuel-Injected Recip; 4-stroke – Rotax 912/Rotax 914 63.4-75.8 kw *85/105 hp* AVGAS (100 Octane) 409 L *108 gal*	One Turbofan – Allison AE3007H 32 kN *7,050 lb static thrust* Heavy Fuel (JP-8) 8,176 L *2,160 gal*	One Turbofan – Williams FJ 44-1A 8.45 kN *1,900 lb static thrust* H[illegible]uel (JP-8) – *416 gal*
	WEIGHT: Empty (kg, *lb*) Fuel Weight (kg, *lb*) Payload (kg, *lb*) Max Takeoff (kg, *lb*)	125/138 kg *276/304 lb* 30/ 32 kg *66/ 70 lb* 34/ 34 kg *75/ 75 lb* 195/205 kg *430/ 452 lb*	544 kg *1,200 lb* 136 kg *300 lb* 91 kg *200 lb* 726 kg *1,600 lb*	136 kg *300 lb* 39 kg *85 lb* 27 kg *60 lb* >227 kg *>500 lb*	544 kg *1,200 lb* 295 kg *650 lb* 204 kg *450 lb* 1,043 kg *2,300 lb*	4,055 kg *8,940 lb* 6,668 kg *14,700 lb* 889 kg *1,960 lb* 11,612 kg *25,600 lb*	[illegible]978 kg *4,360 lb* 1,470 kg *3,240 lb* 454 kg *1,000 lb* 3,901 kg *8,600 lb*
	DIMENSIONS: Wingspan (m, *ft*) Length (m, *ft*) Height (m, *ft*)	5.2 m *17.0 ft* 4.3 m *14.0 ft* 1.0 m *3.3 ft*	8.9 m *29.2 ft* 7.0 m *23.0 ft* 1.7 m *5.4 ft*	3.4 m *11.0 ft* 3.0 m *9.9 ft* 1.5 m *5.0 ft*	14.8 m *48.7 ft* 8.1 m *26.7 ft* 2.2 m *7.3 ft*	35.4 m *116.2 ft* 13.5 m *44.4 ft* 4.6 m *15.2 ft*	21.0 m *69 ft* 4.6 m *15 ft* 1.5 m *5 ft*
	AVIONICS: Transponder Navigation	Mode IIIC IFF GPS	Mode IIIC IFF GPS	Mode IIIC IFF GPS and INS	Mode IIIC IFF GPS and INS	Mode I / II / IIIC / IV IFF GPS and INS	Mode IIIC IFF GPS and INS
	LAUNCH & RECOVERY:	Land: RATO, Rail; Runway, (A-Gear) Ship: RATO; Deck w/Net	RATO, Unimproved Runway (200 m)	75m x 30m x 10m "box" (dependent on weight and altitude)	Runway (760 m/*2,500 ft*)	Runway (1,524 m/*5,000 ft*)	Runway (<1,219 m/*<4,000 ft*)
	GUIDANCE & CONTROL:	Remote Control/Preprogrammed	Remote Control/Preprogrammed	Prepgmd/Remote Con/Autopilot & -land	Prepgmd/Remote Control/Autonomous	Preprogrammed/Autonomous	Preprogrammed/Autonomous
Payload & Links	SENSOR(S):	EO or IR	EO and IR	EO and IR (SAR growth)	EO, IR, and SAR	EO, IR, and SAR	EO or SAR
	DATA LINK(S): Type	Uplink: C-band/LOS & UHF Downlink: C-band/LOS	C-band/LOS	C-band/LOS (Digital growth)	C-band/LOS: UHF/MILSATCOM; Ku-band/SATCOM	Ku-band/SATCOM: X-Band CDL/LOS	Ku-band/SATCOM: X-Band CDL/LOS
	Bandwidth: (Hz)	C-band/LOS: 10 Mhz UHF: 600 MHz	20 MHz	4.4–5.0/5.25–5.85 GHz	C-band/LOS: 20 MHz UHF/MILSATCOM: 25 kHz Ku-band/SATCOM: 5 MHz	UHF/SATCOM: 25 kHz Ku-band/SATCOM: 2.2-72 MHz X-band CDL/LOS: 10-120 MHz	UHF/SATCOM: 25 kHz Ku-band/SATCOM: 2.2 MHz X-band CDL/LOS: 10-60 MHz
	Data Rate: (bps)	C-band/LOS & UHF: 7.317 kbps	7.317 kbps	Full Duplex: 9,600 baud	C-band/LOS: 20 MHz Analog UHF/MILSATCOM: 4.8 kbps Ku-band/ SATCOM: 1.544 Mbps	UHF/SATCOM: 19.2 kbps Ku-band/SATCOM: 1.5-50 Mbps X-band CDL/LOS: 274 Mbps	UHF/SATCOM: 19.2 kbps Ku-band/SATCOM: 1.5 Mbps X-band CDL/LOS: 137 Mbps
	C2 LINK(S):	Through Data Link	Through Data Link	Through Data Link	UHF/MILSATCOM	UHF MILSATCOM: Ku-band/SATCOM; UHF/LOS; X-band CDL/LOS	UHF MILSATCOM: Ku-band/SATCOM; UHF/LOS; X-band CDL/LOS
System & Support	SYSTEM COMPOSITION:	5 AVs, 9 payloads (5 day cameras, 4 FLIRs), 1 GCS, 1 PCS, 1–4 RRSs, 1 TML (USMC units only)	8 AVs, 8 MOSPs, 4 ADRs, 4 RVTs, 3 GCSs/MPSs, 2 GDTs, 1 LRS, 1 MMF	4 AVs, 2 GCSs, 2 GDTs, 1 RVT, 4 MMPs, LRE, GSE	4 AVs, 1 GCS, 1 Trojan Spirit II Dissemination System, GSE	AVs (TBD); HAE CGS	AVs (TBD); HAE CGS
	PRIME/KEY CONTRACTOR(S):	Pioneer UAV, Inc.	TRW Avionics & Surveillance Group	Alliant Techsystems	General Atomics-Aeronautical Systems	Teledyne Ryan Aeronautical	Lockheed Martin Skunk Works/ Boeing Military Aircraft Division
	MAJOR SUBCONTRACTORS: – Air Vehicle, Propulsion, Avionics, Payloads, Information Processing, Communications, Ground and Support Systems	AAI Corp; Computer Instrument Corp; General Svcs Engrg; Humphrey; Israel Aircraft Industries (IAI); Sachs; Trimble Navigation	Alaska Ind.; Burtek; Consolidated Ind.; Fiber Com; Gichner; IAI/Malat; IAI/Elta; IAI/Malat/Tamam; ITT/Cannon; Lopardo: Mechtronics; Moto Guzzi	Bendix King; BMS; Cirrus Design; CDL; FLIR Systems; GS Engineering; IAI Tamam; IntegriNautics; Lockheed Martin; Mission Technologies; Phototelesis-TI; Rockwell International; SwRI; Stratos Group; Teftec Inc.	Boeing Defense & Space; Litton; LMTCS (Ku-band SATCOM); Magnavox/ Carlyle Gp; Northrop Grumman (SAR); Rotax Cp; Versatron Cp	Allison Engine/Rolls Royce; Raytheon E-Systems; GDE Systems/Tracor; Héroux; Hughes Aircraft; Lockheed Martin Wideband Systems; Rockwell International; Aurora Flight Sciences	ABS Cp; Advanced Composites; Aydin Vector; CI Fiberite; Hexcel; Honeywell Avionics; Litton G&C; Lockheed Martin Wideband Systems; Recon/Optical; Rockwell Collins; Rosemount Aerospace; Northrop Grumman; Williams International
	Column Notes:	*AV weights: Option 2 / Option 2+*		*Developmental estimates*		*Developmental estimates*	

Legend:

ADR	Air Data Relay
A-Gear	Arresting Gear
AV	Air Vehicle
AVGAS	Aviation Gasoline
CDL	Common Data Link
CGS	Common Ground Segment
EO	Electro-Optical
FLIR	Forward-Looking Infrared
GCS	Ground Control Station
GDT	Ground Data Terminal
GPS	Global Positioning System
GSE	Ground Support Equipment
HAE	High Altitude Endurance
IFF	Identification Friend or Foe
INS	Inertial Navigation System
IR	Infrared
JP	Jet Petroleum
kHz	Kilohertz
LHA	Landing Helicopter Amphibious
LHD	Landing Helicopter Dock
LOS	Line of Sight
LPD	Landing Platform Dock
LRE	Launch & Recovery Equipment
LRS	Launch & Recovery System
MAE	Medium Altitude Endurance
MHz	Megahertz
MMF	Mobile Maintenance Facility
MMP	Modular Mission Payload
MOGAS	Mobility Gasoline
MOSP	Multi-mission Optronic Stabilized Payload
MPS	Mission Planning Station
PCS	Portable Control Station
RATO	Rocket-Assisted Takeoff
RRS	Remote Receiving Station
RVT	Remote Video Terminal
SATCOM	Satellite Communications (Military)
TML	Truck-Mounted Launcher
UHF	Ultra High Frequency

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